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Recycling of oceanic lithosphere: Water, fO_2 and Fe-isotope constraints

M. BIZIMIS^{1*}, A. H. PESLIER², C. A. MCCAMMON³, S.
KESHAV⁴, H. M. WILLIAMS⁵

¹EOS, Univ. of South Carolina, Columbia, SC 29208, USA
(*correspondence:mbizimis@geol.sc.edu)

²Jacobs, NASA Johnson Space Center, Houston, TX 77058,
USA; anne.h.peslier@nasa.gov

³Bayerisches Geoinstitut, Univ. of Bayreuth, GERMANY,
[catherine.mccammon@uni-bayreuth.de]

⁴Univ. of Montpellier, Montpellier, FRANCE
keshav@gm.univ-montp2.fr

⁵Dept. of Earth Sciences, Durham U., Durham, UK
h.m.williams2@durham.ac.uk

Spinel peridotite and garnet pyroxenite xenoliths from Hawaii provide important clues about the composition of the oceanic lithosphere, and can be used to assess its contribution to mantle heterogeneity upon recycling.

The peridotites have lower bulk H₂O (~70-114 ppm) than the MORB source, qualitatively consistent with melt depletion. The garnet pyroxenites (high pressure cumulates) have higher H₂O (200-460 ppm, up to 550 ppm accounting for phlogopite) and low H₂O/Ce ratios (<100). The peridotites have relatively light Fe-isotopes ($\delta^{57}\text{Fe} = -0.34$ to 0.13) that decrease with increasing depletion, while the pyroxenites are significantly heavier ($\delta^{57}\text{Fe}$ up to 0.3). The observed xenolith, as well as MORB and OIB total Fe-isotope variability is larger than can be explained by existing melting models.

The high H₂O and low H₂O/Ce ratios of pyroxenites are similar to estimates of EM-type OIB sources, while their heavy $\delta^{57}\text{Fe}$ are similar to some Society and Cook-Austral basalts. Therefore, recycling of mineralogically enriched oceanic lithosphere (i.e. pyroxenites) may contribute to OIB sources and mantle heterogeneity.

The Fe³⁺/Σ□□ systematics of these xenoliths also suggest that there might be lateral redox gradients within the lithosphere, between juxtaposed oxidized spinel peridotites ($\Delta\text{FMQ} = -0.7$ to 1.6, at 15 kb) and more reduced pyroxenites ($\Delta\text{FMQ} = -2$ to -0.4, at 20-25kb). Such mineralogically and compositionally imposed fO_2 gradients may generate local redox melting due to changes in fluid speciation (e.g. reduced fluids from pyroxenite encountering more oxidized peridotite). Formation of such incipient, small degree melts could further contribute to metasomatic features seen in peridotites, mantle heterogeneity, as well as the low velocity

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and high electrical conductivity structures near the base of the
lithosphere and upper mantle.